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VARIATION IN AGE STRUCTURE OF THE INCIDENTAL KILL OF SPOTTED DOLPHINS, Stenella attenuata, IN THE U.S. TROPICAL PURSE-SEINE FISHERY

By

Warren E. Stuntz

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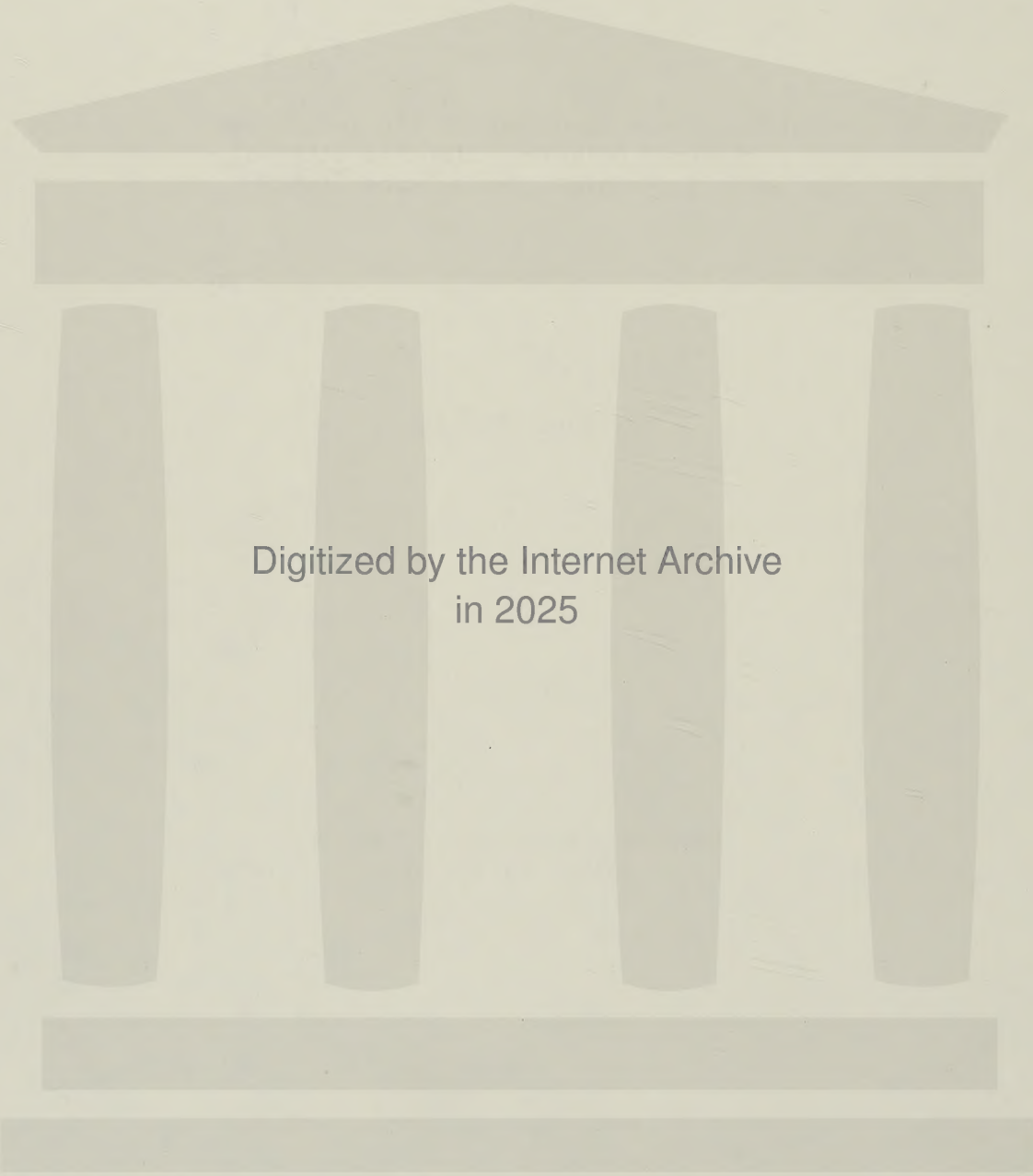
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La Jolla, California

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VARIATION IN AGE STRUCTURE OF THE INCIDENTAL KILL OF SPOTTED DOLPHINS,
STENELLA ATTENUATA, IN THE U.S. TROPICAL PURSE-SEINE FISHERY

by
Warren E. Stuntz
National Marine Fisheries Service
Southwest Fisheries Center
La Jolla, California 92038

INTRODUCTION

During the 1979 SOPS Workshop, an analysis by D. Goodman of the age structure of the dolphin populations indicated that the stocks were likely to be in serious condition due to a shortage of younger age classes in the samples (Smith (ed) 1979). At the time of the analysis, W. Perrin warned that there were serious problems with the tooth readings and the samples upon which the analysis was based, and that the data could be seriously biased to the point where no useful conclusions could be drawn from the data as far as age structure is concerned. Shortly after the workshop, NMFS personnel developed a plan for a multi-phase analysis of all available data to determine what the age structure of the populations were.

This report is an attempt to deduce from the observer data how representative the life history samples collected from spotted dolphins, Stenella attenuata, killed in the purse seine fishery may be. To date, I have analyzed only the observer data and have not yet done crosscorrelations between the life history and observer data.

The analyses reported here were also designed to investigate variations in the age structure of the spotted dolphin kill by purse seiners so as to allow selection of life history specimens from situations where there is the greatest likelihood that the samples will be unbiased and thus reflect the true age structure of the population.

METHODS

Given the age-structure information on the animals that are killed and also the data recorded for each purse seine set, it is possible to ask questions about how the age structure of the kill varies under various conditions. For example, I have addressed the questions of how age structure of the kill varies as a function of year, season of the year, length of chase, time of day, tons of yellowfin caught, school size, the size of the kill and the type of school involved (pure spotted dolphin versus mixed spinner and spotted dolphin schools). If variation of the age structure as a function of any of these variables is detected, it indicates that care is needed in selecting the sample of life history specimens for developing an estimate of the real age structures of the populations.

Based on analyses done by Perrin, spotted dolphins progress through several identifiable color patterns during their growth. These color patterns represent fairly distinct phases in the early life history of the animal and

are used by observers in categorizing the observed kill. For definitions of the color phases see Perrin, Coe and Zweifel (1976). Based on observations of growth rates, etc., the changes in color pattern extend over several years. Five patterns (neonate, two-tone, speckled, mottled and adult) are recognizable. The neonate color pattern lasts about 4.8 months based on the growth-rate data of Perrin, et al. (1976). The two-tone, speckled and mottled color patterns are each believed to last about one year. The final color pattern, adult, is of course, an inclusive category for all animals that survive past the mottled stage.

Throughout the observer data, there is also an "unknown" category. The unknown category can be for sex, where color pattern was observed, or it can cover both age and sex when they are unknown.

The following variables were extracted from the observer data bases (See Table 1): position, cruise number, set number, year, month, day, school type, spotted-dolphin school size, spinner- dolphin school size, number of spotted dolphins captured, number of spinner dolphins captured, number of spotted dolphins killed, number of spinner dolphins killed, tons of yellowfin tuna caught, tons of skipjack tuna caught, time of day; the kill of males, females, unknown sex and total for neonates, two-tones, speckled, mottled and adult spotted dolphins, the number of unknown age or unsexed spotted dolphins killed, the length of the chase to capture the school (in minutes), the fishing area (inside the CYRA, outside the CYRA, and south of the equator), the five-degree square for the set, the quarter of the year, and the observer's best estimate of the number and species initially in the school and the numbers captured. These data on 8321 sets were analyzed using the Biomed statistical package on University of California, San Diego's VAX computer. Prior to the age structure analysis, the data on age- structures were transformed into proportions. This calculation was done for each set and consisted of dividing the number of each age class/sex combination by the total numbers of spotted dolphins killed in the set. Throughout the remainder of this report, age-structure results are given in terms of proportions or mean proportions.

The second step in the analysis was to delete all sets in which there was no spotted-dolphin kill. This reduced the sample size from over 8000 sets to about 3000 sets. The next step in the analysis was to sort the data by the various categories (year, for example), and then, determine if there were observable trends among the cells.

This report presents the results from the preliminary analyses described above. It is important to realize that while many of the results presented are suggestive and may well be real, the final analysis will require a great deal more time and the application of relatively sophisticated statistical knowledge to determine the validity of the hypotheses.

RESULTS

The results are presented as a description of the effects on the age structure of the kill for each variable.

Year. Since 1975, the proportion of neonates in the kill (Table 2) has declined steadily. While only partial data are presently available for 1979,

the proportion of neonates in the kill is least for that year. The pattern in the data for two-tone animals is one year with a high abundance of two-tones, followed by a year where the two-tones represent a smaller proportion of the kill; i.e., 1974 was high, 1975 low, 1976 high, 1977 low, etc. A similar pattern is present in the speckled data until 1979, which is apparently high. Adult and mottled age classes show no particular trend or pattern among years.

Quarter of Year. (Table 3) The proportion of neonates in the kill is strongly correlated with season of the year. The proportion of neonates in the kill peaks in the first quarter of the year and then declines steadily. The proportion of neonates in the kill for the fourth quarter is less than half of that in the first quarter. There is no trend apparent for the two-tone animals, although the proportion of two-tones is highest during the last quarter and the first quarter. The speckled age class shows a trend equivalent to that of the neonates as do the mottled animals, although the decline over the course of the year is much smaller than it is for the neonates. The trend for adults, of course, is opposite to that for the neonates, speckled, and mottled age classes. The proportion of adults in the kill increases throughout the year, with the peak occurring during the fourth quarter.

Area. (Table 4) Only neonates show an effect by area. The proportion of neonates in the kill is highest inside the CYRA and is lowest in the area south of the equator. The value outside the CYRA is intermediate.

School size. (Table 5) The proportions of various age classes in the kill show no trends that appear associated with spotted-dolphin school size. The only age class that seems to have different proportions in kills taken from different school sizes is the neonate class. The proportion of neonates in the kill is nearly twice as great in spotted dolphin schools containing 50 or fewer animals than they are in other school sizes.

Tons of yellowfin tuna caught. (Table 6) Tuna catch is well known to affect the total kill of porpoise. When, however, one breaks down the kill by age classes, some surprising facts appear. Neonates are killed proportionately less in sets with a large catch of tuna. For speckled, mottled, and adult animals, there is a slight trend of increase in the proportion killed with an increase in the catch of tuna.

Length of chase. (Table 7) In general, the proportion of neonates in the kill decreases with an increase in the duration of the chase. For the other age classes, no trend is present.

Size of the kill. (Table 8) The proportion of neonates in the kill varies with the size of the kill. Neonates form a proportionately much larger part of the kill when 2 or less animals are killed than they do when over 40 animals are killed.

Combined analyses. See attached Tables 9 through 13.

The proportions of neonates killed when analyzed by area and quarter of year, Table 9, show very different patterns. For example, the proportion of neonates in the kill decreases steadily throughout the year for the area inside the CYRA, whereas for the area south of the equator, the abundance of

neonates peaks during the 2nd quarter. No sets were made outside the line during the first quarter, but during the second and succeeding quarters there is a steady decline in the proportion of neonates in the kill. The proportion of two-tones in the kill peaks during the fourth quarter for the area inside the CYRA; but for the area south of the equator, the highest proportion of two-tones in the kill occurs during the first quarter of the year. Once again the trend for the area outside of the CYRA follows that of the inside area. The proportions of speckled animals in the kill decrease throughout the year both inside the CYRA and south of the equator, with the exception of the 3rd quarter in the south where the sample includes only 3 sets. The proportion of adults in the kill increases throughout the year both inside the CYRA and south of the equator, (once again excepting the 3rd quarter in the South).

In general, the other analyses (see Tables 10-17) using combinations of variables behave as expected from the preceding analyses, except when sample sizes decrease to the point where the means become unstable.

DISCUSSION

The analyses presented herein are a cause for concern in any attempt to derive the actual population age structure from samples of the kill. There are so many variables that affect (or at least are correlated with) the age structure of the kill, that it is probably impossible to identify a sample and say that it is representative of the overall population(s). Stratification by (at least) area, year, and season will be necessary, and adjustment or stratification to compensate for factors biasing samples may also be necessary.

Some caution must be exercised in interpreting these results. There are two reasons for this. First, the use of proportions means that the proportions of one age class in the kill are related to each of the other age classes. Thus, a major change in one age class will affect the proportions of the other age classes. This situation could lead to invalid conclusions. Further analyses will be needed to either confirm or deny the results presented.

The second reason for caution is that there may be many alternative explanations for the observed trends. I have tried to point out some of the alternatives but there may still be more that I have not considered. The important fact is that something is going on with the population age structure that needs to be explained before we can be complacent about the status of the dolphin stocks.

The results of these analyses, if confirmed by further analysis, may lead to a number of conclusions, some of which may indicate that the dolphin populations are seriously stressed. The decrease in the proportion of neonates in the kill over the years may be evidence of a change in the population structure. A changing population structure may indicate an unstable population. The fact that the proportion of neonates in the kill is highest within the CYRA may indicate a reproductive response by the populations to fishing mortality, but the indication that even with such a response the proportion of neonates is declining with time could mean that gross reproduction is declining due to the nature of mortality imposed by the

fishing operation. Alternately, the decline in the proportion of neonates with time could indicate density-dependent decreasing net reproduction as the population recovers. There are other alternatives as well, such as the possibility that some other organism is removing enough of the resources that the population is moving toward a new low level and that the decrease in neonates is a response to intra-specific rather than inter-specific competition. The presently available data are unable to distinguish between these possibilities.

Another alternative explanation could be that the decrease in the proportion of neonates in the kill over time is related to differential effectiveness of the gear modifications and rescue techniques. The time course of the decreasing proportions of neonates is not exactly in concordance with the net modifications, but the modifications may explain at least a part of the observed trend.

Other things, such as the change in the proportion of neonates killed relative to the length of the chase, could be playing a role in the decrease in the proportion of neonates in the kill over time. If neonates are unable to keep up with the main school during the longer chases, they may become highly susceptible to predation or may become victims of capture stress (Stuntz and Shay, 1979). In either case, they are likely to be lost to the population. Another factor is that neonates tend to be killed selectively in those sets in which the total dolphin kill is small (Powers and Barlow, 1979). Since most kills are now small (almost half of all sets with a kill resulted in a kill of 2 or less animals and well over half of the sets killed 5 or less) the net effect is that the neonates have a higher mortality rate than might be expected.

A possible alternative explanation for the decreasing proportion of neonates killed in sets with increased chase length is that schools with fewer neonates tend to be more difficult to capture. There are presently no data available on this possibility.

The proportion of neonates in the kill is seasonally dependent. Since the majority of the fishing effort is made during the period when neonates are presumably most abundant, this is another potential factor in the decrease in the proportion of neonates with time.

The relationship between tons of yellowfin tuna taken and the proportion of neonates in the kill is less clear. It may be that because larger amounts of yellowfin are associated with capturing larger numbers of dolphins that the chases are longer, resulting in the observation that fewer neonates, proportionately, are killed with large catches of tuna. It should also be noted here that the largest proportion of neonates in the kill is found in schools of 50 or fewer spotted dolphins.

A final interesting finding from this analysis is that there may be seasonal differences in reproductive behavior between animals north and south of the equator. Unfortunately, the sample sizes south of the equator are small and thus don't allow many comparisons (i.e., one cannot do the analysis by month, due to too many empty cells). The finding of seasonality in reproduction indicates that there may be biases in our analyses of reproductive rates (see also the analysis by J. Barlow, SOPS/79/26). Since

the knowledge of reproductive rates is so critical to the proper assessment of the status of the dolphin stocks, this is an area of research that should be actively pursued.

This analysis is preliminary and will need to be extended and refined before the extent of the biases described can be quantified fully, with well defined confidence intervals placed around the estimates. I feel that the findings from the analysis to this point are an indication of potentially serious problems for the dolphin populations and as such merit much more work. The results could be very useful in increasing our ability to make rational management decisions. It also strikes me as important to utilize these results to point out areas where field investigations are needed to resolve certain questions. For example, what is happening to the neonates during a chase? By using a helicopter to observe what happens during the chase and, particularly, to attempt to get a rough estimate of age of any animals that escape through the speedboats, it may be possible to get some idea of what happens to the neonates during the chase.

Another area of needed research is on reproductive periodicity and behavior. Are the breeding seasons critical? Is the calving period(s) critical? Should fishermen be restricted from setting on small schools of dolphins? These are all important questions that need to be addressed. The difficulties and expense of obtaining answers to these questions will be large, but they may be critical for the dolphin populations.

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- Smith, T. (ed.) 1979. Report of the status of porpoise stocks workshop (August 27-31, 1979, La Jolla, California), SWFC Admin. Rept. No. LJ-79-41, 120p.
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Table 1. Summary of data used in the analysis.

Variable No. Name	Mean	Standard Deviation	St. Err. of mean	Coeff. of variation	S M A L L E S T		L A R G E S T		Range	Total Frequency
					Value	Z-score	Value	Z-score		
1 Position	*****	*****	*****	0.45511	*****	-2.20	*****	3.28	*****	8268
2 Cruise set	265697.352	127315.205	1395.7014	0.47917	54007.000	-1.66	502023.000	1.86	448016.000	8321
3 Year	76.710	1.444	0.0158	0.01883	74.000	-1.88	79.000	1.59	5.000	8321
4 Month	5.612	3.172	0.0348	0.56525	1.000	-1.45	12.000	2.01	11.000	8321
5 Day	15.706	8.598	0.0943	0.54740	1.000	-1.71	31.000	1.78	30.000	8321
6 School type	1.910	0.996	0.0109	0.52142	1.000	-0.91	3.000	1.09	2.000	8321
7 Spotted dolphin school size	1214.163	1403.286	15.8983	1.15576	0.000	-0.87	9999.000	6.26	9999.000	7791
8 Spinner dolphin school size	176.762	494.674	5.5857	2.79853	0.000	-0.36	8999.100	17.83	8999.100	7843
9 Spotters captured	680.580	863.991	9.7803	1.26949	0.000	-0.79	9999.000	10.79	9999.000	7804
10 Spinners captured	83.523	255.222	2.8878	3.05569	0.000	-0.33	5152.800	19.86	5152.800	7811
11 Spotters killed	4.557	20.522	0.2250	4.50303	0.000	-0.22	658.000	31.84	658.000	8317
12 Spinners killed	2.141	10.458	0.1147	4.88486	0.000	-0.20	249.000	23.61	249.000	8317
13 Tons of yellowfin tuna	12.748	16.859	0.1848	1.32249	0.000	-0.76	223.000	12.47	223.000	8321
14 Tons of skipjack	0.384	2.054	0.0225	5.34898	0.000	-0.19	50.000	24.15	50.000	8320
15 Time of day(minutes)	714.756	197.470	2.1674	0.27628	334.000	-1.93	1161.000	2.26	827.000	8301
16 Male neonates	0.048	0.341	0.0037	7.05515	0.000	-0.14	11.000	32.13	11.000	8321
17 Female neonates	0.051	0.317	0.0035	6.22623	0.000	-0.16	7.000	21.96	7.000	8321
18 Unknown neonates	0.103	0.671	0.0074	6.54171	0.000	-0.15	40.000	59.50	40.000	8321
19 Sum of neonates	0.202	0.956	0.0105	4.74183	0.000	-0.21	40.000	41.62	40.000	8321
20 Male two-tones	0.184	0.927	0.0102	5.03437	0.000	-0.20	37.000	39.72	37.000	8321
21 Female two-tones	0.188	0.955	0.0105	5.09273	0.000	-0.20	42.000	43.76	42.000	8321
22 Unknown two-tones	0.219	1.356	0.0149	6.19421	0.000	-0.16	58.000	42.63	58.000	8321
23 Sum of two-tones	0.591	2.502	0.0274	4.23738	0.000	-0.24	36.000	34.13	36.000	8321
24 Male speckled	0.157	0.832	0.0091	5.29434	0.000	-0.19	52.000	43.10	52.000	8321
25 Female speckled	0.160	0.945	0.0104	5.89286	0.000	-0.17	82.000	54.83	82.000	8321
26 Unknown speckled	0.150	1.400	0.0154	9.32879	0.000	-0.11	96.000	58.45	96.000	8321
27 Sum of speckled	0.468	2.360	0.0259	5.04760	0.000	-0.20	31.000	40.47	31.000	8321
28 Male mottled	0.143	0.761	0.0083	5.33136	0.000	-0.19	43.000	40.54	43.000	8321
29 Female mottled	0.187	0.950	0.0104	5.08547	0.000	-0.20	102.000	45.05	102.000	8321
30 Unknown mottled	0.157	1.683	0.0185	10.72453	0.000	-0.09	102.000	60.50	102.000	8321
31 Sum of mottled	0.487	2.525	0.0277	5.18924	0.000	-0.19	102.000	40.20	102.000	8321
32 Sum of speckled and mottled	0.954	4.696	0.0515	4.92085	0.000	-0.20	188.000	39.83	188.000	8321
33 Male adult	0.429	2.202	0.0241	5.12819	0.000	-0.20	90.000	40.68	90.000	8321
34 Female adult	0.567	2.425	0.0266	4.27873	0.000	-0.23	80.000	32.76	80.000	8321
35 Unknown adult	0.444	5.044	0.0553	11.36799	0.000	-0.09	400.00	79.22	400.000	8321
36 Sum of adult	1.440	7.225	0.0792	5.01809	0.000	-0.20	400.00	55.16	400.000	8321
37 Age unknown	1.088	11.879	0.1302	10.91606	0.000	-0.09	624.000	52.44	624.000	8283
38 Chase	31.598	19.250	0.2115	0.60920	2.000	-1.54	203.000	8.90	201.000	8260
39 Area	1.270	0.537	0.0059	0.42305	1.000	-0.50	3.000	3.22	2.000	8321
40 Five degree square	121.156	79.617	0.8728	0.65715	8.000	-1.42	999.000	11.03	991.000	8321
41 Quarter of year	2.225	1.027	0.0113	0.46153	1.000	-1.19	4.000	1.73	3.000	8321
42 Observers' best est. of spotters' best est.	1041.964	1224.989	16.8648	1.17565	0.000	-0.85	9999.000	7.31	9999.000	5276
43 Observers' best est. of spinner sch'l. sz.	145.776	372.717	5.1313	2.55678	0.000	-0.39	4500.000	11.68	4500.000	5276
44 Observers' best est. of spotters capt'd	614.361	747.639	10.5595	1.21694	0.000	-0.82	9799.000	12.28	9799.000	5013
45 Observers' best est. of spinners capt'd	62.371	171.679	2.4248	2.75253	0.000	-0.36	2275.000	12.89	2275.000	5013

Table 2. Average proportions of each age class in the spotted dolphin kill by year.

Year	Neonate	Two-tone	Speckled	Mottled	Speckled and Mottled	Adult	Age* unknown	Number (N) of Sets
1974	0.077	0.208	0.152	0.101	0.253	0.408	0.137	509
1975	0.189	0.160	0.127	0.134	0.261	0.340	0.121	540
1976	0.109	0.191	0.123	0.117	0.240	0.410	0.130	562
1977	0.067	0.160	0.108	0.121	0.229	0.491	0.172	876
1978	0.057	0.209	0.127	0.132	0.259	0.426	0.132	486
1979**	0.025	0.174	0.187	0.162	0.349	0.404	0.247	160

* The unknown age proportions have been prorated over the other age classes.

** 1979 data are from the 1st half of the year

Table 3. Average proportions of each age class in the spotted dolphin kill as a function of season of the year for 1974-part of 1979.

Yr Qtr	Neonate	Two-tone	Speckled	Mottled	Speckled and mottled	Adult	Age* unknown	Number of sets
1st	0.136	0.213	0.157	0.144	0.301	0.426	0.275	1320
2nd	0.119	0.198	0.152	0.148	0.300	0.491	0.301	694
3rd	0.078	0.196	0.144	0.136	0.280	0.536	0.304	951
4th	0.059	0.243	0.108	0.126	0.234	0.579	0.281	409

*The unknown age proportions have been prorated over the other age classes.

Table 4. Average proportions of each age class in the spotted dolphin kill by area, 1974 through part of 1979.

Area	Neonate	Two-tone	Speckled	Mottled	Adult	Age* unknown	N
Inside CYRA	0.100	0.184	0.126	0.119	0.419	0.141	2570
Outside CYRA	0.077	0.157	0.137	0.128	0.451	0.165	616
South	0.055	0.216	0.121	0.145	0.414	0.185	188
Mean	0.092	0.181	0.128	0.122	0.425	0.148	3374

* The unknown age proportions have been prorated over the other age classes

Table 5. Average proportions of each age class in the spotted dolphin kill as a function of estimated spotted school size 1974 through part of 1979.

School size	Neonate	Two-tone	Spotted	Mottled	Speckled and mottled	Adult	Age unknown	Number of Sets
≤50	0.176	0.088	0.174	0.136	0.310	0.379	0.085	30
51-100	0.065	0.268	0.184	0.092	0.276	0.357	0.198	55
101-250	0.106	0.152	0.141	0.115	0.256	0.447	0.128	251
251-500	0.088	0.187	0.123	0.114	0.237	0.442	0.175	508
501-1000	0.107	0.177	0.127	0.118	0.245	0.418	0.143	813
1001-2500	0.093	0.191	0.120	0.128	0.229	0.419	0.142	940
>2500	0.080	0.185	0.133	0.137	0.270	0.413	0.152	536

*The unknown age proportions are prorated over the other age classes.

Table 6. Average proportions of each age class in the spotted dolphin kill as a function of the tons of yellowfin tuna (YF) caught 1974 through part of 1979.

YF catch	Neonate	Two-tone	Speckled	Mottled	Adult	Age unknown	Number of sets
≤1	0.123	0.216	0.118	0.089	0.373	0.197	295
2-5	0.106	0.188	0.116	0.120	0.427	0.173	627
6-10	0.115	0.165	0.132	0.114	0.418	0.158	638
11-20	0.086	0.191	0.133	0.119	0.423	0.141	790
21-30	0.084	0.172	0.131	0.138	0.427	0.120	427
>30	0.063	0.170	0.131	0.138	0.455	0.136	633
Mean	0.096	0.184	0.127	0.120	0.420	0.154	3410

Table 7. Average proportions of each age class in the spotted dolphin kill as a function of the length of the chase necessary to capture the school 1974 through part of 1979.

Length Chase (min)	Neonate	Two-tone	Speckled	Mottled	Adult	Age unknown	Number of sets
<10	0.128	0.172	0.139	0.119	0.411	0.154	228
11-20	0.111	0.203	0.115	0.119	0.397	0.161	789
21-30	0.085	0.165	0.144	0.115	0.437	0.156	930
31-40	0.099	0.173	0.126	0.139	0.418	0.150	610
41-50	0.064	0.184	0.104	0.131	0.467	0.145	406
51-60	0.070	0.200	0.130	0.118	0.406	0.119	209
>60	0.091	0.178	0.140	0.104	0.446	0.141	238
Mean	0.093	0.181	0.127	0.123	0.425	0.151	3410

Table 8. Average proportions of each age class in the spotted dolphin kill as a function of the total number of spotters killed in the set 1974 through part of 1979.

Kill	Neonate	Two-tone	Speckled	Mottled	Adult	Age unknown	Number of sets
≤ 2	0.109	0.179	0.127	0.110	0.438	0.139	1503
3-5	0.101	0.180	0.116	0.122	0.412	0.136	718
6-10	0.078	0.193	0.124	0.129	0.416	0.128	478
11-40	0.070	0.180	0.144	0.144	0.411	0.193	518
> 40	0.040	0.175	0.144	0.155	0.430	0.254	193
Mean	0.081	0.182	0.131	0.131	0.421	0.170	3410

Table 9. Average proportion of each age class in the spotted dolphin kill by area and quarter of year over the years 1974 through part of 1979.

Area	1st	Quarter of Year 2nd	3rd	4th
Neonates				
Inside	0.110	0.089	0.052	0.044
Outside	*	0.071	0.062	0.055
South	0.031	0.127	0.000*	0.013
Two-tone				
Inside	0.153	0.150	0.150	0.190
Outside	*	0.123	0.132	0.139
South	0.196	0.132	0.000*	0.067
Speckled				
Inside	0.119	0.118	0.084	0.086
Outside	*	0.091	0.126	0.056
South	0.100	0.092	0.333*	0.013
Mottled				
Inside	0.105	0.101	0.101	0.091
Outside	*	0.133	0.096	0.114
South	0.124	0.095	0.000*	0.122
Speckled and Mottled				
Inside	0.224	0.219	0.185	0.177
Outside	*	0.224	0.221	0.170
South	0.224	0.187	0.333*	0.135
Adult				
Inside	0.318	0.353	0.401	0.430
Outside		0.379	0.365	0.441
South	0.310	0.330	0.667*	0.517
Unknown age				
Inside	0.139	0.145	0.159	0.119
Outside	*	0.178	0.164	0.117
South	0.188	0.171	0.000*	0.230
Number of Sets				
Inside	1176	515	518	361
Outside	0*	151	430	35
South	144	28	3*	13

* Sample size is very small.

Table 10. Quarter of year and length of chase.

Chase Length	Quarter of Year			
	<u>1st</u>	<u>2nd</u>	<u>3rd</u>	<u>4th</u>
<u>Neonates</u>				
≤10 min.	0.127	0.105	0.055	0.000
11-20	0.123	0.081	0.049	0.049
21-30	0.094	0.076	0.054	0.028
31-40	0.089	0.096	0.073	0.070
41-50	0.069	0.054	0.059	0.022
51-60	0.099	0.095	0.038	0.018
>60	0.035	0.149	0.049	0.095
<u>Two-tone</u>				
≤10 min.	0.129	0.163	0.247	0.048
11-20	0.167	0.165	0.149	0.237
21-30	0.142	0.126	0.149	0.128
31-40	0.175	0.122	0.128	0.167
41-50	0.166	0.153	0.141	0.178
51-60	0.138	0.207	0.132	0.283
>60	0.218	0.107	0.108	0.203
<u>Speckled</u>				
≤10 Min.	0.129	0.099	0.105	0.072
11-20	0.090	0.155	0.071	0.070
21-30	0.132	0.094	0.133	0.086
31-40	0.127	0.102	0.100	0.071
41-50	0.094	0.095	0.097	0.055
51-60	0.099	0.128	0.113	0.117
>60	0.183	0.094	0.096	0.115
<u>Mottled</u>				
≤10 Min.	0.097	0.103	0.119	0.088
11-20	0.106	0.099	0.097	0.075
21-30	0.104	0.107	0.078	0.101
31-40	0.108	0.147	0.120	0.091
41-50	0.122	0.109	0.090	0.142
51-60	0.145	0.075	0.112	0.059
>60	0.094	0.077	0.105	0.072
<u>Speckled and Mottled</u>				
≤10 Min.	0.227	0.201	0.223	0.160
11-20	0.197	0.253	0.168	0.145
21-30	0.236	0.201	0.211	0.187
31-40	0.236	0.249	0.220	0.162
41-50	0.215	0.203	0.187	0.197
51-60	0.244	0.202	0.224	0.176
>60	0.277	0.171	0.200	0.187
<u>Adult</u>				
≤10 Min.	0.342	0.330	0.307	0.572
11-20	0.318	0.306	0.361	0.359
21-30	0.306	0.369	0.399	0.496
31-40	0.332	0.359	0.349	0.428
41-50	0.270	0.434	0.446	0.451
51-60	0.357	0.306	0.376	0.360
>60	0.313	0.385	0.423	0.409

Age unknown				
≤ 10 Min.	0.13	0.163	0.168	0.220
11-20	0.132	0.160	0.199	0.185
21-30	0.165	0.187	0.136	0.112
31-40	0.116	0.133	0.192	0.126
41-50	0.216	0.124	0.114	0.099
51-60	0.079	0.122	0.143	0.116
>60	0.130	0.144	0.171	0.060
Number of Sets				
≤10 Min.	141	51	24	11
11-20	384	145	177	72
21-30	383	169	261	108
31-40	199	130	201	71
41-50	107	98	134	65
51-60	50	44	80	35
>60	56	57	74	47

Table 11. Average proportion of each age class in the spotted dolphin kill by total spotter kill and tons of yellowfin tuna over the years 1974 through part of 1979.

Tons	Spotter Kill				
	<u>≤ 2</u>	<u>3-5</u>	<u>6-10</u>	<u>11-40</u>	<u>> 40</u>
Neonates					
≤ 1	0.115	0.093	0.092	0.039	0.013
2- 5	0.104	0.072	0.067	0.048	0.030
6-10	0.106	0.095	0.084	0.064	0.037
11-20	0.084	0.079	0.062	0.058	0.024
21-30	0.062	0.110	0.062	0.072	0.024
> 30	0.059	0.078	0.053	0.048	0.031
Two-tone					
≤ 1	0.180	0.179	0.179	0.113	0.054
2- 5	0.156	0.159	0.175	0.111	0.116
6-10	0.140	0.130	0.136	0.150	0.095
11-20	0.158	0.181	0.171	0.161	0.097
21-30	0.148	0.124	0.186	0.151	0.161
> 30	0.138	0.146	0.167	0.139	0.139
Speckled					
≤ 1	0.107	0.067	0.099	0.066	0.051
2- 5	0.087	0.093	0.111	0.135	0.095
6-10	0.113	0.110	0.099	0.114	0.069
11-20	0.125	0.097	0.117	0.105	0.089
21-30	0.120	0.109	0.094	0.117	0.139
> 30	0.106	0.102	0.111	0.125	0.111
Mottled					
≤ 1	0.079	0.088	0.047	0.036	0.026
2- 5	0.093	0.098	0.113	0.109	0.106
6-10	0.086	0.101	0.120	0.100	0.088
11-20	0.087	0.100	0.127	0.117	0.112
21-30	0.129	0.103	0.100	0.132	0.158
> 30	0.106	0.125	0.116	0.127	0.115
Speckled and Mottled					
≤ 1	0.186	0.156	0.146	0.102	0.078
2- 5	0.180	0.192	0.224	0.245	0.201
6-10	0.199	0.211	0.219	0.215	0.157
11-20	0.212	0.197	0.244	0.222	0.201
21-30	0.250	0.211	0.194	0.249	0.297
> 30	0.213	0.227	0.227	0.252	0.225
Adult					
≤ 1	0.324	0.323	0.222	0.203	0.146
2- 5	0.359	0.344	0.338	0.341	0.227
6-10	0.360	0.331	0.358	0.313	0.348
11-20	0.400	0.343	0.363	0.291	0.272
21-30	0.396	0.385	0.371	0.328	0.326
> 30	0.436	0.385	0.412	0.379	0.338
Number of Sets					
≤ 1	161	56	40	31	7
2- 5	366	120	75	56	10
6-10	336	151	79	63	9

11-20	347	178	111	122	32
21-30	166	91	63	91	16
>30	127	122	110	155	119

Table 12. Average proportion of each age class in the spotted dolphin kill by the total spotter kill and chase length over the years 1974 through part of 1979.

Chase Length	Spotter Kill				
	<u>≤2</u>	<u>3-5</u>	<u>6-10</u>	<u>11-40</u>	<u>>40</u>
Neonates					
≤10 min.	0.140	0.123	0.092	0.042	0.051
11-20	0.113	0.082	0.091	0.071	0.028
21-30	0.080	0.091	0.057	0.050	0.031
31-40	0.086	0.115	0.058	0.077	0.019
41-50	0.072	0.036	0.056	0.032	0.027
51-60	0.076	0.058	0.060	0.039	0.022
>60	0.109	0.069	0.043	0.052	0.042
Two-tone					
≤10 min.	0.133	0.159	0.177	0.128	0.134
11-20	0.180	0.159	0.182	0.145	0.141
21-30	0.120	0.158	0.159	0.153	0.120
31-40	0.142	0.148	0.149	0.162	0.125
41-50	0. 73	0.138	0.176	0.127	0.111
51-60	0.194	0.151	0.194	0.137	0.158
>60	0.173	0.150	0.151	0.111	0.112
Speckled					
≤10 min.	0.118	0.134	0.108	0.094	0.130
11-20	0.090	0.080	0.106	0.119	0.104
21-30	0.132	0.107	0.099	0.127	0.112
31-40	0.107	0.103	0.116	0.103	0.086
41-50	0.074	0.087	0.111	0.106	0.101
51-60	0.109	0.111	0.128	0.124	0.103
>60	0.134	0.099	0.105	0.122	0.116
Mottled					
≤10 min.	0.086	0.098	0.118	0.113	0.122
11-20	0.100	0.091	0.096	0.108	0.116
21-30	0.072	0.114	0.113	0.113	0.131
31-40	0.114	0.115	0.115	0.140	0.112
41-50	0.112	0.102	0.136	0.107	0.081
51-60	0.102	0.088	0.116	0.125	0.092
>60	0.072	0.105	0.100	0.098	0.095
Speckled and Mottled					
≤10 min.	0.204	0.231	0.226	0.207	0.252
11-20	0.190	0.170	0.202	0.226	0.220
21-30	0.204	0.222	0.212	0.240	0.243
31-40	0.222	0.218	0.231	0.243	0.198
41-50	0.187	0.189	0.247	0.212	0.182
51-60	0.211	0.199	0.244	0.249	0.195
>60	0.206	0.204	0.205	0.220	0.210
Adult					
≤10 min.	0.391	0.330	0.292	0.323	0.285
11-20	0.319	0.353	0.331	0.322	0.323
21-30	0.411	0.318	0.359	0.315	0.315
31-40	0.369	0.349	0.357	0.336	0.270
41-50	0.415	0.387	0.414	0.349	0.367

51-60	0.365	0.347	0.354	0.336	0.339
>60	0.352	0.447	0.451	0.317	0.328
Number of Sets					
≤10 min.	93	50	35	38	12
11-20	331	175	119	126	38
21-30	413	186	144	131	56
31-40	281	133	72	85	39
41-50	188	76	51	71	20
51-60	96	44	25	28	16
>60	101	54	32	39	12

Table 13. Average proportion of each age class in the spotted dolphin kill by tons of yellowfin tuna and chase length over the years 1974 through part of 1979.

	Chase Length						
Tons	≤10 min.	11-20	21-30	31-40	41-50	51-60	>60
Neonates							
≤1	0.132	0.118	0.103	0.076	0.044	0.138	0.057
2- 5	0.109	0.101	0.063	0.093	0.105	0.068	0.085
6-10	0.103	0.105	0.093	0.108	0.052	0.072	0.120
11-20	0.123	0.055	0.067	0.095	0.042	0.057	0.119
21-30	0.121	0.114	0.051	0.077	0.055	0.056	0.048
>30	0.062	0.079	0.065	0.041	0.038	0.017	0.038
Two-tone							
≤1	0.126	0.221	0.137	0.169	0.141	0.150	0.200
2- 5	0.141	0.144	0.124	0.165	0.162	0.246	0.206
6-10	0.142	0.165	0.123	0.123	0.148	0.121	0.103
11-20	0.125	0.172	0.156	0.170	0.172	0.193	0.142
21-30	0.212	0.158	0.144	0.129	0.161	0.160	0.121
>30	0.150	0.172	0.141	0.120	0.141	0.155	0.148
Speckled							
≤1	0.090	0.072	0.114	0.123	0.064	0.100	0.079
2- 5	0.071	0.083	0.130	0.073	0.085	0.104	0.095
6-10	0.126	0.097	0.118	0.137	0.072	0.082	0.125
11-20	0.120	0.106	0.127	0.099	0.084	0.128	0.147
21-30	0.121	0.108	0.104	0.119	0.112	0.173	0.104
>30	0.170	0.100	0.118	0.100	0.098	0.104	0.137
Mottled							
≤1	0.073	0.045	0.082	0.091	0.048	0.133	0.063
2- 5	0.075	0.091	0.070	0.143	0.119	0.128	0.078
6-10	0.126	0.114	0.078	0.093	0.075	0.108	0.071
11-20	0.090	0.091	0.115	0.093	0.135	0.051	0.085
21-30	0.063	0.124	0.095	0.145	0.163	0.115	0.128
>30	0.152	0.118	0.121	0.142	0.091	0.100	0.097
Speckled and Mottled							
≤1	0.163	0.117	0.195	0.213	0.111	0.233	0.141
2- 5	0.145	0.174	0.201	0.216	0.204	0.231	0.173
6-10	0.252	0.211	0.195	0.231	0.147	0.190	0.197
11-20	0.210	0.197	0.242	0.192	0.219	0.179	0.233
21-30	0.184	0.231	0.199	0.264	0.276	0.288	0.233
>30	0.322	0.218	0.239	0.242	0.189	0.204	0.234
Adult							
≤1	0.323	0.271	0.250	0.287	0.389	0.310	0.334
2- 5	0.393	0.306	0.410	0.327	0.331	0.311	0.370
6-10	0.304	0.338	0.355	0.301	0.404	0.394	0.443
11-20	0.385	0.329	0.354	0.386	0.387	0.363	0.340
21-30	0.358	0.313	0.388	0.376	0.389	0.365	0.446
>30	0.301	0.399	0.381	0.391	0.445	0.365	0.369
Number of Sets							
≤1	26	76	75	41	29	18	30
2- 5	42	165	169	111	61	43	36
6-10	51	173	165	116	63	39	31
11-20	50	168	230	151	98	38	55
21-30	24	87	118	73	58	29	38
>30	35	120	173	118	97	42	48

Table 14. Average proportion of each age class in the spotted dolphin kill by area and year.

<u>Year</u>	<u>Inside</u>	<u>Area Outside</u>	<u>South</u>
Neonates			
1974	0.066	0.057	0
1975	0.177	0.051	0.063
1976	0.101	0.099	0.047
1977	0.048	0.059	0.080
1978	0.056	0.034	0.040
1979	0.024	0.000	0.018
Two-tone			
1974	0.180	0.306	0
1975	0.135	0.109	0.169
1976	0.187	0.130	0.186
1977	0.144	0.079	0.079
1978	0.184	0.161	0.201
1979	0.113	0.083	0.179
Speckled			
1974	0.126	0.175	0
1975	0.112	0.059	0.065
1976	0.094	0.123	0.115
1977	0.083	0.101	0.118
1978	0.116	0.110	0.051
1979	0.153	0.042	0.091
Mottled			
1974	0.083	0.120	0
1975	0.119	0.028	0.097
1976	0.097	0.098	0.126
1977	0.098	0.096	0.102
1978	0.100	0.132	0.094
1979	0.130	0.125	0.129
Speckled and Mottled			
1974	0.209	0.294	0
1975	0.231	0.087	0.162
1976	0.191	0.221	0.241
1977	0.181	0.197	0.220
1978	0.216	0.242	0.145
1979	0.283	0.167	0.220
Adult			
1974	0.350	0.251	0
1975	0.298	0.183	0.332
1976	0.354	0.358	0.338
1977	0.404	0.425	0.405
1978	0.372	0.371	0.388
1979	0.337	0.208	0.254
Number of Sets			
1974	538	29	0
1975	535	18	10
1976	283	204	83
1977	762	196	20
1978	334	168	30
1979	134	2	45

Table 15. Average proportion of each age class in the spotted dolphin kill by quarter of year and year.

<u>Year</u>	<u>1st</u>	<u>Quarter 2nd</u>	<u>3rd</u>	<u>4th</u>
<u>Neonates</u>				
1974	0.058	0.157	0.024	0.077
1975	0.209	0.071	0.101	0.048
1976	0.072	0.119	0.100	0.072
1977	0.000	0.080	0.042	0.029
1978	0.043	0.048	0.058	0.037
1979	0.018	0.036	0	0
<u>Two-tone</u>				
1974	0.169	0.164	0.307	0.250
1975	0.127	0.153	0.119	0.184
1976	0.198	0.178	0.138	0.103
1977	0.208	0.125	0.123	0.156
1978	0.180	0.155	0.153	0.242
1979	0.132	0.120	0	0
<u>Speckled</u>				
1974	0.127	0.114	0.179	0.113
1975	0.112	0.102	0.112	0.087
1976	0.103	0.111	0.110	0.105
1977	0.417	0.097	0.090	0.057
1978	0.084	0.167	0.115	0.093
1979	0.146	0.101	0	0
<u>Mottled</u>				
1974	0.087	0.059	0.109	0.074
1975	0.113	0.168	0.029	0.103
1976	0.108	0.104	0.096	0.091
1977	0.083	0.097	0.094	0.110
1978	0.131	0.098	0.115	0.073
1979	0.123	0.153	0	0
<u>Speckled and Mottled</u>				
1974	0.214	0.172	0.289	0.188
1975	0.225	0.270	0.141	0.190
1976	0.211	0.215	0.206	0.196
1977	0.500	0.194	0.184	0.167
1978	0.216	0.265	0.230	0.166
1979	0.270	0.254	0	0
<u>Adult</u>				
1974	0.362	0.293	0.255	0.325
1975	0.273	0.321	0.279	0.477
1976	0.322	0.364	0.357	0.431
1977	0.208	0.375	0.411	0.459
1978	0.344	0.332	0.388	0.418
1979	0.291	0.398	0	0
<u>Number of Sets</u>				
1974	425	50	45	47
1975	411	83	29	40
1976	198	150	170	52
1977	3	295	504	176
1978	150	81	204	97
1979	141	40	0	0

Table 16. Average proportion of each age class in the spotted dolphin kill by tons of yellowfin tuna and chase over the years 1974 through part of 1979.

Chase length	Tons					Over 30
	≤1	2-5	6-10	11-20	21-30	
Neonates						
≤10 min.	0.156	0.095	0.117	0.116	0.137	0.044
11-20	0.126	0.105	0.102	0.055	0.114	0.086
21-30	0.108	0.068	0.091	0.070	0.048	0.063
31-40	0.077	0.094	0.105	0.105	0.082	0.043
41-50	0.045	0.100	0.055	0.047	0.053	0.039
51-60	0.146	0.074	0.081	0.066	0.068	0.017
>60	0.063	0.096	0.105	0.131	0.043	0.038
Two-tone						
≤10 min.	0.127	0.151	0.155	0.119	0.216	0.148
11-20	0.199	0.138	0.169	0.163	0.148	0.171
21-30	0.140	0.128	0.121	0.160	0.144	0.138
31-40	0.173	0.170	0.127	0.170	0.128	0.124
41-50	0.145	0.159	0.156	0.185	0.148	0.143
51-60	0.159	0.264	0.106	0.203	0.143	0.155
>60	0.194	0.227	0.120	0.156	0.129	0.130
Speckled						
≤10 min.	0.106	0.066	0.131	0.110	0.102	0.186
11-20	0.078	0.083	0.102	0.113	0.106	0.098
21-30	0.119	0.132	0.115	0.132	0.105	0.120
31-40	0.126	0.073	0.139	0.099	0.110	0.096
41-50	0.066	0.088	0.076	0.075	0.118	0.098
51-60	0.076	0.099	0.092	0.144	0.127	0.104
>60	0.050	0.107	0.142	0.149	0.108	0.130
Mottled						
≤10 min.	0.056	0.077	0.122	0.095	0.057	0.158
11-20	0.049	0.092	0.117	0.090	0.129	0.123
21-30	0.080	0.064	0.078	0.120	0.100	0.123
31-40	0.093	0.144	0.092	0.096	0.152	0.141
41-50	0.049	0.123	0.079	0.137	0.160	0.090
51-60	0.111	0.137	0.106	0.047	0.130	0.100
>60	0.033	0.076	0.075	0.075	0.115	0.093
Speckled and Mottled						
≤10 min.	0.162	0.143	0.253	0.205	0.159	0.344
11-20	0.127	0.175	0.220	0.203	0.236	0.221
21-30	0.199	0.196	0.193	0.251	0.205	0.243
31-40	0.219	0.217	0.231	0.195	0.262	0.238
41-50	0.115	0.211	0.155	0.212	0.278	0.188
51-60	0.187	0.236	0.197	0.191	0.257	0.204
>60	0.083	0.183	0.217	0.223	0.223	0.223
Adult						
≤10 min.	0.336	0.383	0.260	0.401	0.349	0.290
11-20	0.280	0.307	0.342	0.336	0.324	0.386
21-30	0.260	0.403	0.361	0.335	0.381	0.379
31-40	0.269	0.325	0.315	0.375	0.369	0.388
41-50	0.367	0.334	0.424	0.378	0.389	0.446

Table 16 (Continued):

51-60	0.329	0.296	0.368	0.311	0.394	0.365
> 60	0.362	0.326	0.425	0.313	0.447	0.389
Number of Sets						
≤10 min.	22	38	45	44	21	32
11-20	70	153	158	154	80	110
21-30	71	157	157	218	110	170
31-40	40	106	110	134	68	110
41-50	28	59	60	88	51	94
51-60	17	40	35	30	24	42
>60	27	30	25	46	34	45

Table 17. Average proportion of each age class in the spotted dolphin kill by spotted dolphin school size and chase length, over the years 1974 through part of 1979.

Chase length	≤50	51-100	101-250	251-500	501-1000	1001-2500	Over 2500
Neonates							
≤10 min.	0.167	0.215	0.081	0.113	0.107	0.114	0.062
11-20	0.000	0.069	0.110	0.096	0.115	0.076	0.068
21-30	0.233	0.000	0.095	0.055	0.074	0.073	0.068
31-40	0.333	0.000	0.107	0.076	0.104	0.084	0.069
41-50	0.000	0.063	0.011	0.030	0.085	0.061	0.035
51-60	0.000	0.000	0.029	0.034	0.094	0.051	0.091
>60	0.000	0	0.000	0.031	0.006	0.133	0.081
Two-tone							
≤10 min.	0.222	0.143	0.093	0.179	0.143	0.142	0.162
11-20	0.071	0.234	0.116	0.143	0.168	0.195	0.138
21-30	0.022	0.145	0.115	0.114	0.135	0.163	0.147
31-40	0.037	0.264	0.183	0.173	0.158	0.115	0.147
41-50	0.146	0.188	0.185	0.218	0.117	0.161	0.162
51-60	0.000	1.000	0.254	0.129	0.163	0.198	0.154
>60	0.250	0	0.000	0.184	0.164	0.142	0.164
Speckled							
≤10 min.	0.000	0.067	0.097	0.110	0.067	0.231	0.180
11-20	0.348	0.094	0.147	0.082	0.093	0.068	0.163
21-30	0.154	0.286	0.135	0.117	0.137	0.104	0.110
31-40	0.000	0.100	0.074	0.096	0.093	0.124	0.111
41-50	0.219	0.000	0.093	0.081	0.089	0.102	0.066
51-60	0.500	0.000	0.042	0.171	0.139	0.092	0.068
>60	0.000		0.083	0.075	0.152	0.089	0.146
Mottled							
≤10 min.	0.000	0.009	0.113	0.081	0.146	0.085	0.086
11-20	0.071	0.043	0.083	0.093	0.097	0.118	0.130
21-30	0.109	0.016	0.100	0.087	0.102	0.097	0.109
31-40	0.407	0.164	0.068	0.105	0.101	0.135	0.132
41-50	0.146	0.625	0.153	0.126	0.073	0.104	0.134
51-60	0.385	0.000	0.163	0.062	0.144	0.093	0.084
>60	0.000	0	0.167	0.054	0.059	0.086	0.092
Speckled and Mottled							
≤10 min.	0.000	0.076	0.210	0.191	0.213	0.316	0.266
11-20	0.420	0.137	0.229	0.174	0.190	0.186	0.294
21-30	0.263	0.302	0.235	0.204	0.239	0.200	0.218
31-40	0.407	0.264	0.142	0.201	0.194	0.258	0.243
41-50	0.365	0.625	0.246	0.207	0.163	0.207	0.200
51-60	0.885	0.000	0.205	0.233	0.283	0.185	0.153
>60	0.000	0	0.250	0.129	0.211	0.175	0.238
Adult							
≤10 min.	0.278	0.287	0.432	0.275	0.385	0.317	0.281
11-20	0.384	0.258	0.370	0.372	0.315	0.337	0.243
21-30	0.447	0.293	0.391	0.413	0.342	0.341	0.359
31-40	0.074	0.371	0.412	0.311	0.349	0.366	0.337
41-50	0.219	0.125	0.307	0.356	0.420	0.404	0.403
51-60	0.000	0.000	0.333	0.447	0.301	0.315	0.393

Table 17 (Continued):

>60	0.750	0	0.250	0.263	0.459	0.384	0.341
Number of Sets							
≤10 min.	6	7	31	54	54	32	18
11-20	4	18	87	156	198	196	66
21-30	12	17	77	132	228	278	140
31-40	3	10	30	84	155	170	116
41-50	1	2	18	46	97	133	83
51-60	2	1	10	22	44	62	47
>60	1	0	2	20	41	75	68

